3-31-2005

2004 Lamprey River Dissolved Oxygen Study

Jonathan Pennock
University of New Hampshire - Main Campus

2004 Lamprey River Dissolved Oxygen Study

A Final Report to

The New Hampshire Estuaries Project

Submitted by

Dr. Jonathan Pennock
University of New Hampshire
Jackson Estuarine Laboratory
85 Adams Point Road
Durham, NH, 03824

March 31, 2005

This report was funded by a grant from the New Hampshire Estuaries Project, as authorized by the U.S. Environmental Protection Agency pursuant to Section 320 of the Clean Water Act.

Table of Contents

Introduction

As part of the National Estuarine Research Reserve System, the Great Bay System-Wide Monitoring Program (SWMP) produces *in situ* water quality data for four sites in and around Great Bay. In recent years, DataSondes deployed in the upper Lamprey River have documented dissolved oxygen concentrations that do not meet federal standards during a significant portion of the summer and fall period. These low oxygen concentrations, if they persist may have a negative effect on benthic and pelagic organisms in the river and will necessitate management action to improve water quality.

Project Goals and Objectives

UNH completed this project under contract to the NH Estuaries Project (Project ID #04-M-2; CE-991711-06 and CE-991711-08). The project goals and objectives per the contract were to carry out surveys of the Lamprey River during the summer and fall to:

(1) confirm the accuracy of the DataSonde data;

(2) assess whether the DataSonde data are generally representative of the upper reaches of the river; and

(3) gain insight into the potential causes of low oxygen in the bottom waters of the river.

The final work product was agreed to be a summary analysis of survey data and Excel data files containing survey data, relevant DataSonde records along with appropriate meta-data for these data.

Methods

DataSonde deployments followed the procedures generally prescribed by the National Estuarine Research Reserve Central Data Management Office (CDMO) and detailed in Small et al. (2003).

Briefly, YSI 6600 DataSondes are programmed to obtain measurements of specific conductivity, salinity, dissolved oxygen, percent saturation, pH, temperature, water level, and turbidity every half-hour. The instruments are deployed continuously during ice-free seasons, except for brief periods when they are removed for cleaning, maintenance and recalibration. Pre and post-deployment calibrations are performed using the diagnostics menu of the YSI Ecowatch program and QA/QC procedures developed by NERR Research Coordinators and YSI engineers. VWR conductivity and pH standards are used for calibration. YSI formazin is used to calibrate turbidity probes.

DataSondes are deployed approximately one meter from the bottom and recovered for data download every 2-4 weeks depending upon the time of year. Files are first examined and graphed using Ecowatch software. Missing and/or anomalous data are noted. Files are then transferred to a Macintosh computer and opened in Excel software and edited. Missing data due to routine YSI maintenance and probe failure or communication errors are inserted into the spreadsheet. Edited files are merged to contain one full month of data. Files are verified by means of CDMO Excel macros. The CDMO cdmomac3.xls macro allows the user to automatically format column widths to the correct number decimal places based on the YSI sensor specifications. It also allows the user to QA/QC each data logger generated file for missing data points, fill all cells that do not contain data with periods, and find all data points that fall outside the range of what the DataSonde is designed to measure (outliers). The CDMO import.xls macro will allow PC users with 30-minute data to automatically create a monthly Excel file from a two-week deployment and insert periods for missing data. Edited files are merged to contain one full month of data. In addition, in November 1999 a graphing capability was added to this macro allowing users to produce single parameter and missing point graphs on a monthly basis. All files are graphed in Excel and examined in order that anomalous data points can be identified and removed.

Surveys were carried out by small boat on four days in the summer and fall of 2004; 16 July, 29 July, 12 August and 26 October. Originally the surveys were designed to be in response to low dissolved oxygen events observed using near real-time telemetry; however, telemetry for this site could not be established during 2004. As a result, the surveys dates were chosen based on past experience of the time and tidal stages for which low dissolved oxygen, if present, would be expected.

During each survey, sampling was conducted at ~15 stations in the upper basin, ~7 in the tidal river between the basin and Great Bay, and between 2 and 3 times at the DataSonde location (Figure 1). At each station, vertical profiles of specific conductivity, salinity, dissolved oxygen, percent saturation, pH, and temperature were taken using a YSI 6600 DataSonde in approximately 0.5 meter vertical increments. The profiling DataSonde was calibrated on the day of the survey following the CDMO methods outlined above. In addition, location coordinates were obtained using a Magellan Sport Trac hand-held GPS.

Comparisons between DataSonde and survey data were made by using the DataSonde data point (collected every 30 minutes) taken closest to the survey profile and by using the survey profile sample depth closest to the depth of the DataSonde. Maximum differences between the data used in the comparisons was thus, 15 minutes in time and 0.5 meters in depth.

Results and Discussion

The lack of near real-time telemetry during the study period resulted in a shift in study design from the proposed goal of one detailed survey (~22 stations) and four additional surveys (~10 stations each) to four detailed surveys (~22 stations each). This resulted in >88 station profiles as compared to the >62 proposed.

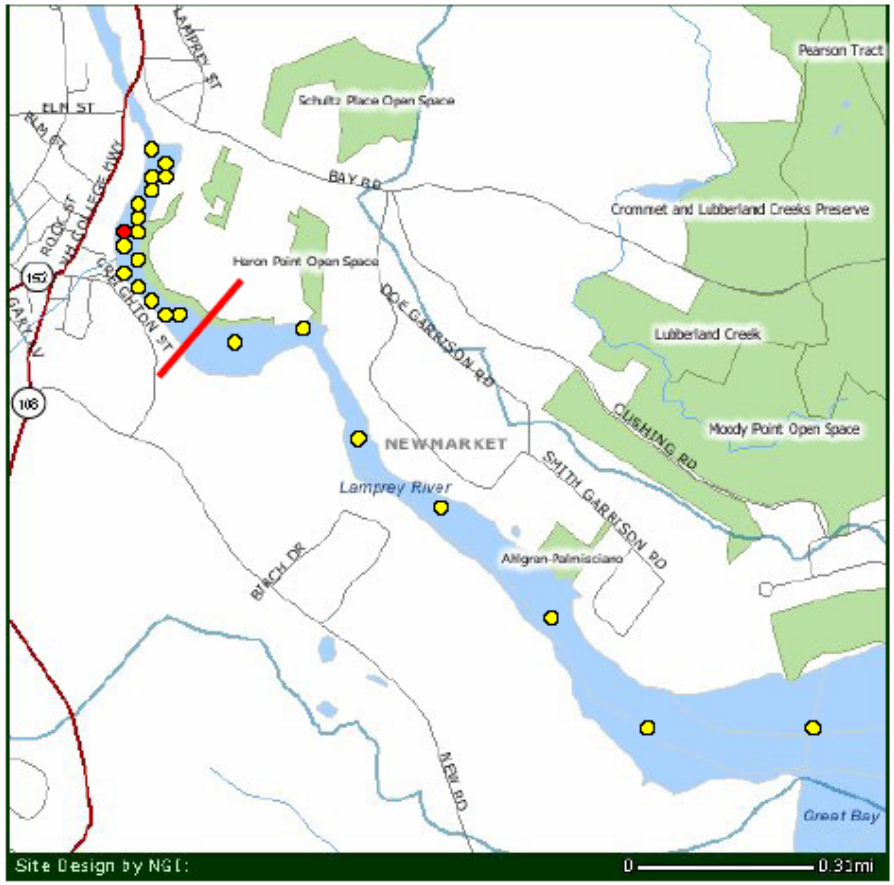
Comparisons of dissolved oxygen saturation and salinity data from the DataSondes with vertical profiles from the four surveys (Figures 2-5) were used to assess the accuracy and reliability of the DataSonde data. For the 16 July, 12 August and 26 October surveys (Figures 2, 3 & 5) the survey profile data was consistent with the DataSonde data. On 29 July, the survey profile data showed higher oxygen levels than the corresponding DataSonde data. The data also displayed a consistent trend of decreasing oxygen concentration/percent saturation with salinity (and depth; see data files).

Figure 1

Lamprey River DO Study

Approximate Station Locations

- **Sonde Station**
- **Cast Stations**
- Arbitrary Division between upper and lower basins



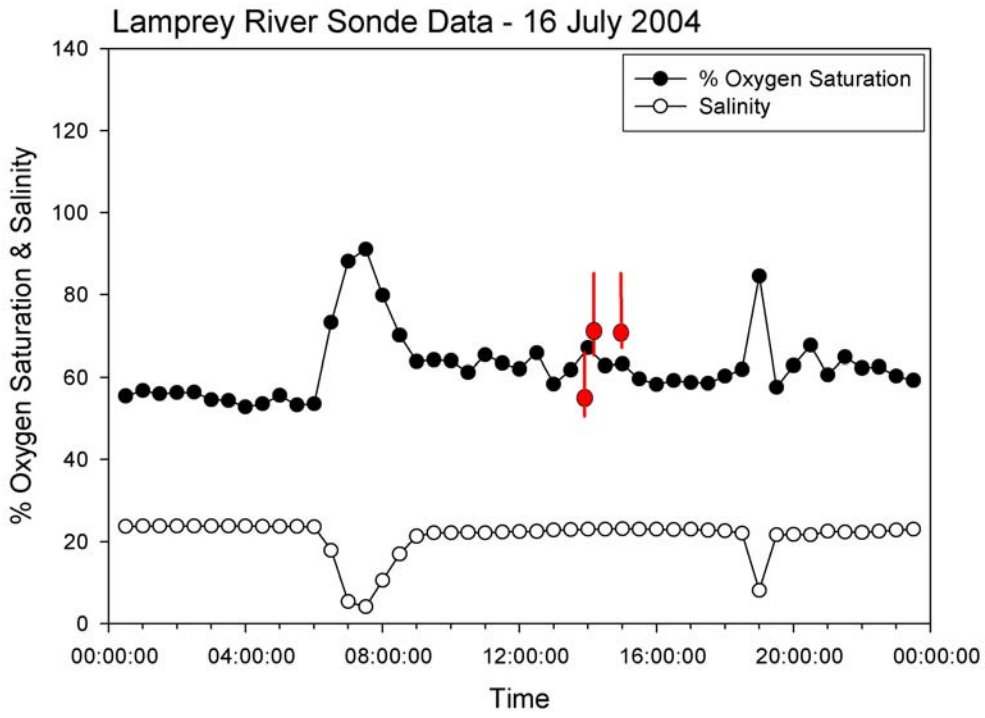


Figure 2 –Oxygen Saturation (solid dots) and Salinity (open dots) data from the Lamprey River DataSonde on 16 July. Red dots (DataSonde depth) and line (range) for vertical casts taken adjacent to the DataSonde during spatial survey on the same date.

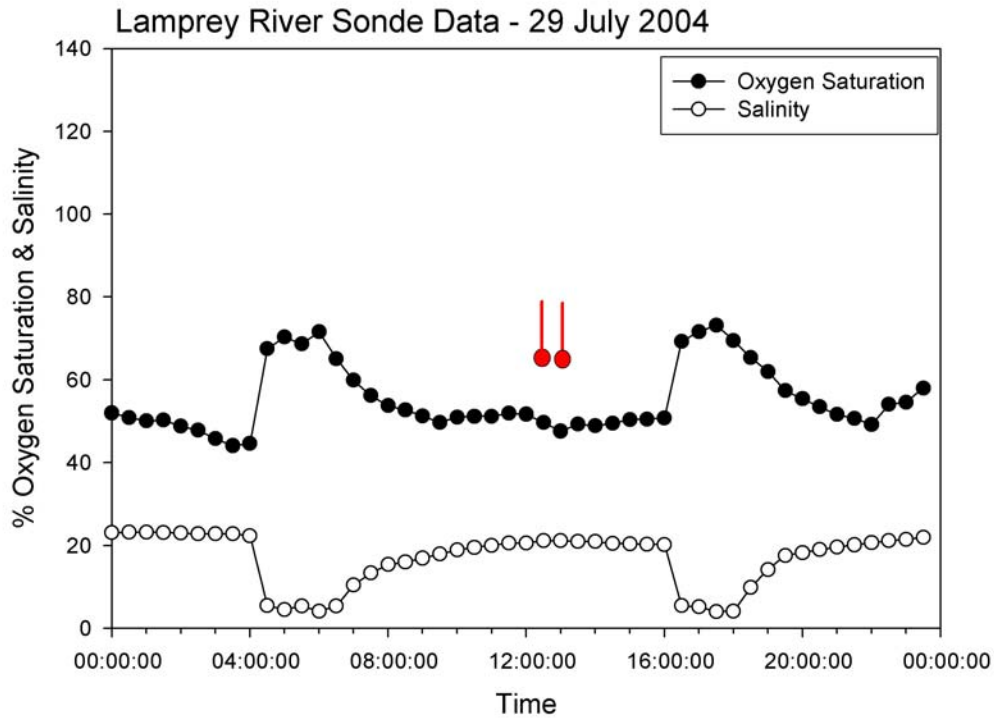


Figure 3 –Oxygen Saturation (solid dots) and Salinity (open dots) data from the Lamprey River DataSonde on 29 July. Red dots (DataSonde depth) and line (range) for vertical casts taken adjacent to the DataSonde during spatial survey on the same date.

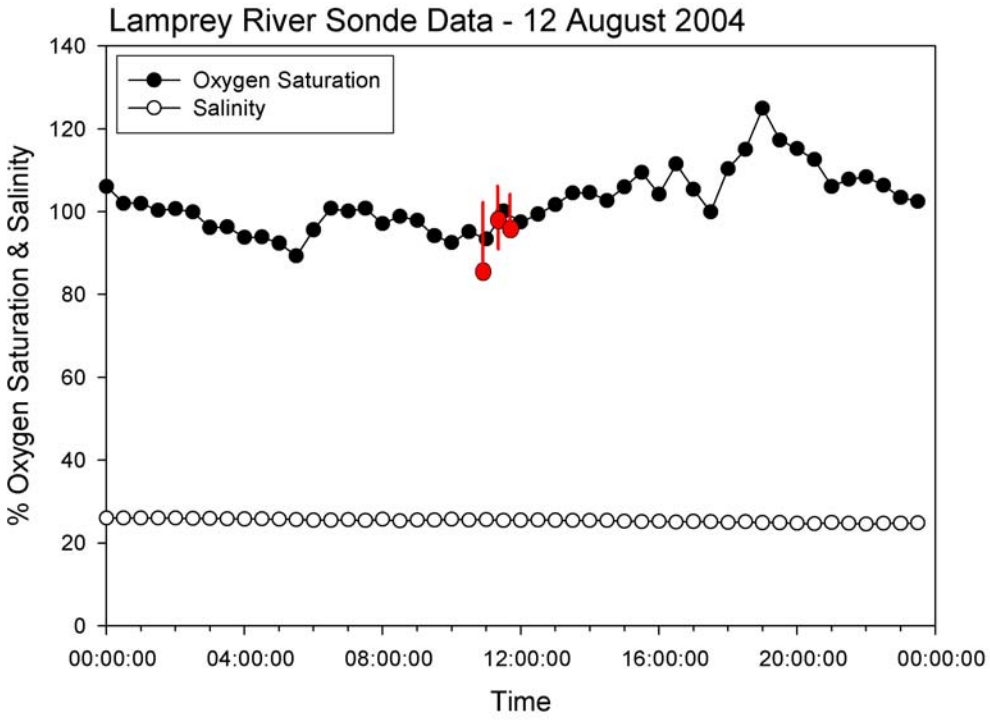


Figure 4 –Oxygen Saturation (solid dots) and Salinity (open dots) data from the Lamprey River DataSonde on 12 August. Red dots (DataSonde depth) and line (range) for vertical casts taken adjacent to the DataSonde during spatial survey on the same date.

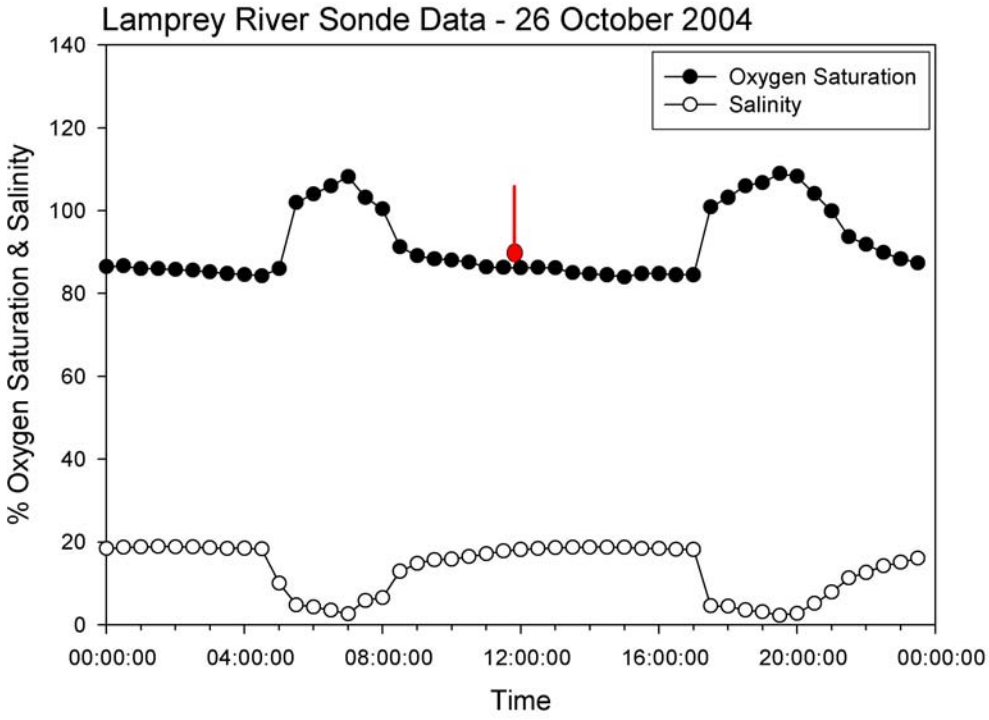


Figure 5 –Oxygen Saturation (solid dots) and Salinity (open dots) data from the Lamprey River DataSonde on 26 October. Red dots (DataSonde depth) and line (range) for vertical casts taken adjacent to the DataSonde during spatial survey on the same date.

Examination of dissolved oxygen saturation and salinity profiles for all of the survey profiles (plotted as box and whisker plots for all data from each profile; Figures 6-9) shows that variation in oxygen concentration in vertical profiles corresponds to variation in salinity. These data also show that, except for the first sample on 16 July, distributions of dissolved oxygen saturation and salinity at the DataSonde location are similar to the distributions observed in the rest of the upper tidal river basin. Both salinity and dissolved oxygen saturation display less vertical variation in the lower river (last 7 stations plotted in Figures 6-9) than in the upper basin.

Conclusions and Recommendations

The *in situ* water quality monitoring program provides important data on basic water quality parameters in the Great Bay estuary. This study confirms that the Lamprey River DataSonde accurately represents the salinity, oxygen and other core hydrographic parameter conditions in the river. There is no indication that the DataSonde is located in an abnormal/poorly mixed region of the river nor is there a suggestion of persistent and inaccurately low oxygen readings.

The vertical profiles taken during the surveys do suggest that there is significant stratification in the upper reaches of the tidal portion of the Lamprey River. These high salinity bottom waters, at times, support low dissolved oxygen concentrations. This is confirmed by the plots of diel DataSonde data during three of the four surveys. During these surveys (Figures 2, 3 & 5) it is apparent that high salinity/low oxygen bottom waters rise up to the DataSonde level during high tides resulting in large fluctuations in both salinity and oxygen saturation values. One would predict that this low oxygen bottom water persists over periods of days to weeks until it is flushed by a major rain event or mixed by particularly strong tidal and/or river currents. The 12 August event (Figure 4) is evidence of such a non-stratified period.

These results suggest that low dissolved oxygen is a concern for the upper tidal reaches of the Lamprey River. Whether this is a long-term (and natural?) characteristic of this system or whether human perturbation (e.g. historic dam building, dredging/deepening of the basin, enrichment of oxygen consuming organic or inorganic runoff/waste, etc…) would require a detailed study of the biological and chemical oxygen demand in the system.

References

Small, Tamara D., Ashly D. Norman, Danna D. Swain, Jesse Friedmann and Dwayne E. Porter. (2003) CDMO NERR SWMP DATA MANAGEMENT MANUAL Version 5.0 (December 2003). NOAA National Estuarine Research Reserve, Centralized Data Management Office, Georgetown, SC.

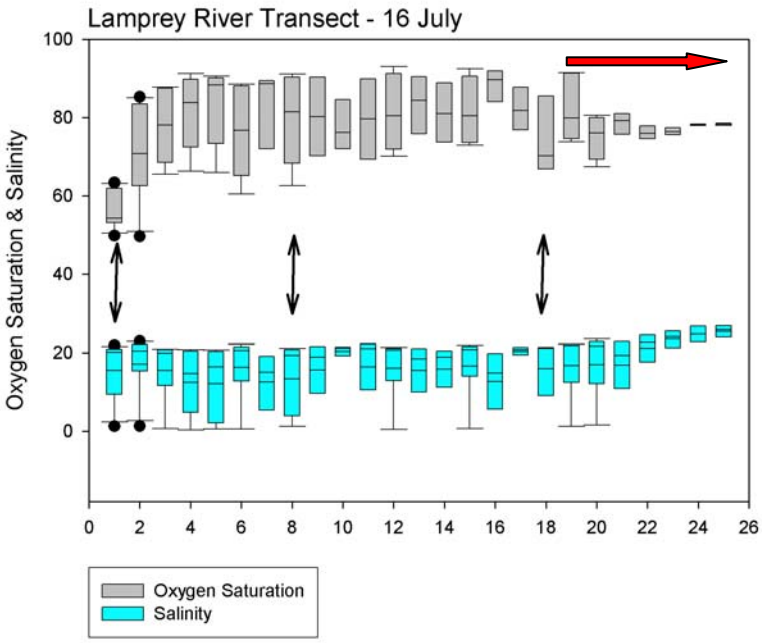


Figure 6 – Box & whisker plots from vertical profiles of Oxygen Saturation (grey) and Salinity (Aqua) in the Lamprey River DataSonde on 16 July. Profiles from the upper basin are to the left and those taken adjacent to the Lamprey River DataSonde are indicated by the black vertical arrows. The last 7 profiles (indicated by the red arrow) are taken from the river. In each box & whisker plot, the horizontal line in the middle of the box represents the mean, the additional horizontal line represents the median, the upper and lower limits of the box represent the 25th and 75th percentiles, the upper and lower whiskers represent the 5th and 95th percentiles and solid cots represent statistical outliers.

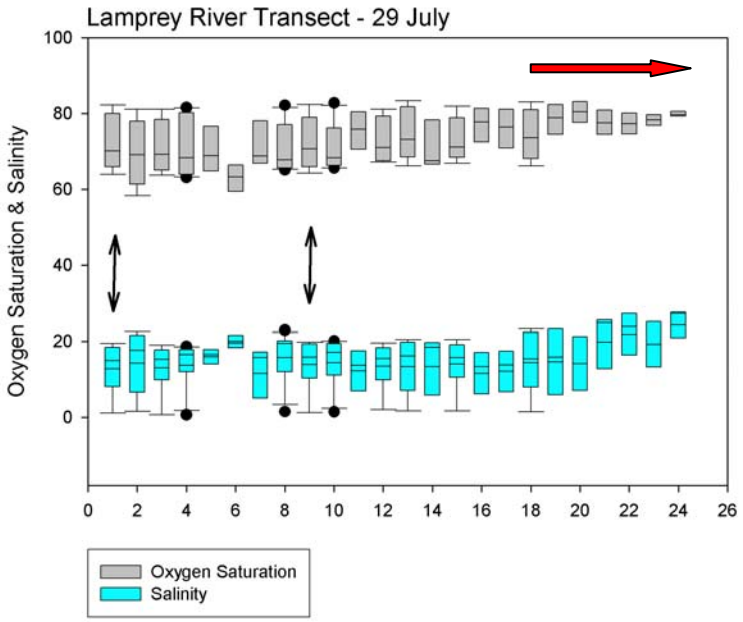


Figure 7 – Box & whisker plots from vertical profiles of Oxygen Saturation (grey) and Salinity (Aqua) in the Lamprey River DataSonde on 29 July. Profiles from the upper basin are to the left and those taken adjacent to the Lamprey River DataSonde are indicated by the black vertical arrows. The last 7 profiles (indicated by the red arrow) are taken from the river. In each box & whisker plot, the horizontal line in the middle of the box represents the mean, the additional horizontal line represents the median, the upper and lower limits of the box represent the 25th and 75th percentiles, the upper and lower whiskers represent the 5th and 95th percentiles and solid cots represent statistical outliers.

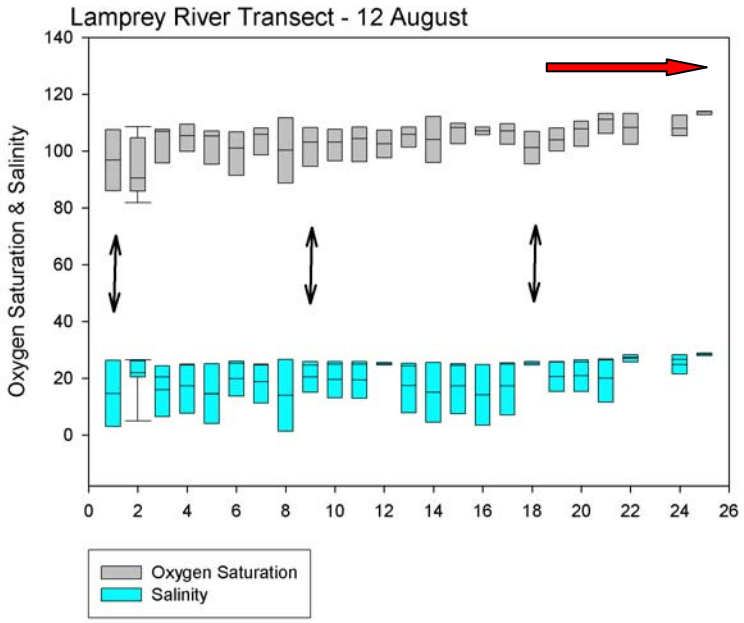


Figure 6 – Box & whisker plots from vertical profiles of Oxygen Saturation (grey) and Salinity (Aqua) in the Lamprey River DataSonde on 12 August. Profiles from the upper basin are to the left and those taken adjacent to the Lamprey River DataSonde are indicated by the black vertical arrows. The last 7 profiles (indicated by the red arrow) are taken from the river. In each box & whisker plot, the horizontal line in the middle of the box represents the mean, the additional horizontal line represents the median, the upper and lower limits of the box represent the 25th and 75th percentiles, the upper and lower whiskers represent the 5th and 95th percentiles and solid cots represent statistical outliers.

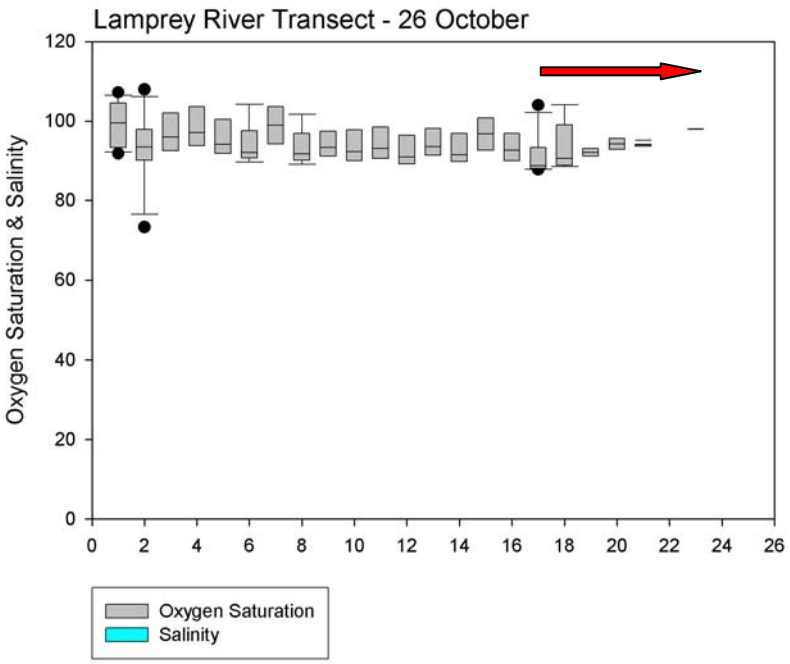


Figure 6 – Box & whisker plots from vertical profiles of Oxygen Saturation (grey) and Salinity (Aqua) in the Lamprey River DataSonde on 26 October. Profiles from the upper basin are to the left and those taken adjacent to the Lamprey River DataSonde are indicated by the black vertical arrows. The last 7 profiles (indicated by the red arrow) are taken from the river. In each box & whisker plot, the horizontal line in the middle of the box represents the mean, the additional horizontal line represents the median, the upper and lower limits of the box represent the 25th and 75th percentiles, the upper and lower whiskers represent the 5th and 95th percentiles and solid cots represent statistical outliers.

2004 Lamprey River Dissolved Oxygen Study Meta-Data (Appendix 1)

Research Methods

Datasondes are programmed to obtain measurements of specific conductivity, salinity, dissolved oxygen, percent saturation, pH, temperature, water level, and turbidity every half-hour. The instruments are deployed continuously during ice-free seasons, except for brief periods when they are removed for cleaning, maintenance and recalibration. Pre and post-deployment calibrations are performed using the diagnostics menu of the YSI Ecowatch program and QA/QC procedures developed by NERR Research Coordinators and YSI engineers. VWR conductivity and pH standards are used for calibration. YSI formazin is used to calibrate turbidity probes.

YSI 6600 datasondes are deployed approximately one meter from the bottom and recovered for data download every 2-4 weeks depending upon the time of years. Files are first examined and graphed using Ecowatch software. Missing and/or anomalous data are noted. Files are then transferred to a Macintosh computer and opened in Excel software and edited. Missing data due to routine YSI maintenance and probe failure or communication errors are inserted into the spreadsheet. Edited files are merged to contain one full month of data. Files are verified by means of CDMO Excel macros. The CDMO cdmomac3.xls macro will allow the user to automatically format column widths to the correct number decimal places based on the YSI sensor specifications. It also allows the user to QA/QC each data logger generated file for missing data points, fill all cells that do not contain data with periods, and find all data points that fall outside the range of what the datalogger is designed to measure (outliers). The CDMO import.xls macro will allow PC users with 30-minute data to automatically create a monthly Excel file from a two-week deployment and insert periods for missing data. Edited files are merged to contain one full month of data. In addition, in November 1999 a graphing capability was added to this macro allowing users to produce single parameter and missing point graphs on a monthly basis. All files are graphed in Excel and examined in order that anomalous data points can be identified.

Missing or Anomalous Data

<u>16 July Survey</u>

- Near Real-Time Telemetry Not Available
- YSI 6600 Profile Surveys conducted using CTD in an autonomous mode that did not allow for targeting the instrument at the pycnocline/oxycline depth

<u>19 July Survey</u>

- Near Real-Time Telemetry Not Available
- YSI 6600 Profile Surveys conducted using CTD in an autonomous mode that did not allow for targeting the instrument at the pycnocline/oxycline depth

<u>12 August Survey</u>

- Near Real-Time Telemetry Not Available
- YSI 6600 Profile Surveys conducted using CTD in an autonomous mode that did not allow for targeting the instrument at the pycnocline/oxycline depth

26 October Survey

- Near Real-Time Telemetry Not Available
- YSI 6600 Profile Surveys conducted using CTD with integrated deck unit that allowed for instantaneous readings
- Salinity data from Profile Surveys was lost during downloading and is unavailable